Understanding regional differences in maternal mortality: a national case-control study in France.

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1.-Title page

Understanding regional differences in maternal mortality: A national case-control study in France.

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Running title: Geographic disparities in maternal mortality

2. Abstract

Objectives: to assess the risk of postpartum maternal death associated with region, and to examine whether the quality of care received by the women who died differed by region.

Design: A national case-control study

Setting: France

Population: selected from recent nationwide surveys, 328 postpartum maternal deaths from 2001 through 2006 as cases; and a representative sample (n=14,878) of women who gave birth in 2003 as controls.

Methods: Crude and adjusted odd ratios of maternal death associated with region were calculated with logistic regression, and the quality of care for cases was compared according to region with chi-square tests or Fisher's exact tests.

Main outcome measures: Risk of postpartum maternal death associated with region, and quality of care.

Results: After adjustment for maternal age and nationality, the risk of maternal death was higher in Ile-de-France region (aOR1.6; 95% CI: 1.2, 2.0) and the overseas districts (aOR3.5; 95% CI: 2.4, 5.0) than in the rest of continental France group. In both regions, the excess risk of death from haemorrhage, amniotic fluid embolism and hypertensive disorders was significant. In continental France, after further controlling for women's obstetric characteristics, the risk of maternal death in Ile-de-France remained higher (aOR1.8; 95%CI: 1.3, 2.6). The cases received suboptimal care more frequently in Ile-de-France than in the rest of continental regions (64% versus 43%, p=0.01).

Conclusions: These results suggest that quality of care and organization of health services may play a role in the differential risk of maternal mortality between regions in France. Research on severe maternal morbidity and its determinants is needed to clarify the mechanisms involved.

Keywords: case-control study, maternal mortality, regional disparities, substandard care.

3. Main body of text

Introduction

Maternal mortality (MM) remains the principal indicator of maternal health, a simultaneous marker of the quality of and access to care [1-4]. The last report from the French National Confidential Enquiry into Maternal Deaths (ENCMM) covered the 2001-2006 period and showed a global maternal mortality ratio (MMR) of 9.6 deaths per 100,000 live births [5]. Although similar to MMRs in other high-resource countries with an enhanced surveillance system [6, 7], this ratio can probably be reduced still further. One approach to this goal is to identify the subgroups of women at increased risk and develop preventive strategies for them. Results in several countries show an association between some individual characteristics, such as advanced age or foreign nationality or geographic origin, and a higher risk of maternal death [8-10]. The implications of these findings in terms of prevention nonetheless remain unclear.

Geographic disparities in MM within the same country are potentially informative but have been studied less [11, 12]. Of the 27 administrative French regions, risk of MM is reported to be highest in the Ile-de-France region (Paris and its suburbs) and in the overseas districts (DOM: French Guyana, Reunion, Guadeloupe and Martinique) than in the rest of continental France, and this excess risk persists after standardization for maternal age [11]. These 2 regions account for 42% of the maternal deaths in France (28% in Ile-de-France and 14% in the DOM), although they account for only 26% of live births (22% in Ile-de-France and 4% in the DOM) [Figure 1]. The reasons for this excess MM remain controversial. Such disparities can result from differences in the women's characteristics but also from heterogeneity in the organization and quality of care.

Although policies governing the organization of health care and clinical guidelines are defined at a national level in France, they are implemented regionally. Understanding the

mechanisms of geographic disparities may help to design customized regional policies focused on specific subgroups and/or modes of health-service organization.

Our objectives were to test the hypothesis that the risk of postpartum maternal death in France remains significantly higher in the Ile-de-France region and the DOM, taking the individual characteristics of women into account and to determine if the quality of care received by the women who died differed according to their region of delivery.

Methods

This study used a case-control design, with both cases and controls selected from recent nationwide surveys.

Population

Cases: Women who died were selected from the ENCMM [5], conducted in France since 1996 and specifically from those who died during the 2001-2006 period. This permanent survey system follows the International Classification of Diseases in defining maternal death (ICD-10th revision) [13] as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by pregnancy or its management but not from accidental or incidental causes.” Deaths with any mention of pregnancy or birth or puerperium, or for which the pregnancy tick box is marked, on review of the death certificate’s content are selected by the national center of statistics for medical causes of death (CépiDc) and reported to the ENCMM. A team of assessors (an obstetrician and an anaesthetist) conducts a confidential enquiry of each death that occurred in the context of a current or recent pregnancy. The assessors use a standardized detailed medical questionnaire to collect the relevant clinical information related to the woman and her death through interviews and a review of hospital records and autopsy reports. Given the non-participation of some local

clinicians, the confidential enquiry is completed and deaths fully documented in only three quarters of maternal deaths identified by the ENCMM. Deaths are then anonymously reviewed by the National Committee of Experts [5], who make a unanimous determination about the underlying cause of death (whether the death is a maternal death, either direct or indirect, according to the ICD definition), its avoidability (certainly, perhaps, or cannot be determined) and the reasons for avoidability (one or more of these reasons: delay in treatment, missed diagnosis, inadequate or insufficient treatment, medical error or patient negligence), and the global quality of medical and obstetric care (not optimal, optimal or cannot be determined) [5]. The surveillance system identified 463 maternal deaths for the 6-year study period considered here. Specifically, this study included the postpartum maternal deaths from that period associated with birth at a gestational age of 22 weeks or more (still- or live births), for consistency with the definition of the controls (*see below*). To avoid possible referral bias, we excluded women who died outside their region of residence. The study population of women who died during the postpartum period therefore included 328 cases [figure 2].

Controls: The control women came from the 2003 French National Perinatal Survey (NPS), a national representative sample of births in France (n=15,108). NPS are repeated cross-sectional studies intended to monitor trends in perinatal health indicators and medical practices. They cover all births (live births and stillbirths) occurring during 1 week in France if they are at a gestational age of 22 weeks or more or weighing at least 500 g. The precise methodology of the 2003 survey has been described elsewhere [14, 15]. Data were collected through interviews with the mother and from medical records. The comparison group for our case-control study thus included women who participated in the 2003 National Perinatal Survey (because it fell in the middle of the 2001–2006 time window for case inclusion) who delivered in their region of residence, for consistency with the definition of the cases. The control sample therefore included 14,878 women [figure 2].

Study variables

The primary predictor variable of interest was the region — the region of delivery for the controls and the region of death for the cases. Regions were classified in three groups: the DOM, Ile-de-France, and other continental regions as the reference group. The following socio-demographic variables examined as potential confounders were the mother's age, nationality, work status and marital status. These data were collected from the interviews of control subjects and from the death certificates for the cases.

We collected the following obstetric characteristics for cases and controls: parity, mode of delivery, multiple birth, and variables considered as markers of preexisting morbidity, i.e., hypertensive disorders during pregnancy, hospitalization during pregnancy, induction of labor, emergency cesarean delivery, and preterm delivery. These data came from the medical records for the controls and from the confidential enquiry for the cases reviewed by the National Committee of Experts. Because the proportion of missing data for these clinical variables was so high in the maternal deaths from the DOM (50%, n=21), they were only analyzed for women from continental France.

Analyses

To test the hypothesis of an excess risk of postpartum maternal death among women from Ile-de-France and the DOM, we used different multivariate logistic regression models. A first model was adjusted for the relevant socio-demographic characteristics in all women and crude and adjusted odds ratios associated with region were assessed, overall and for cause-specific postpartum MM. A second logistic regression analysis included socio-demographic and relevant obstetric characteristics and was conducted only in women from IDF and the rest of continental France; among obstetrics characteristics, hypertension during pregnancy and induced labor were not included in the multivariate model because of significantly different

missing-value rates for cases between regions. The same analysis was conducted in the subgroup of women from continental France with a singleton term delivery (gestational age ≥37 weeks), to eliminate possible residual confounding related to pre-existing morbidity

The last part of the analysis was restricted to the women who died. In this group, we compared quality of care received, avoidability of death and reasons for avoidability, according to geographic region. Again, because of the proportion of missing data for women who died in the DOM, this analysis was limited to the cases from continental France. Proportions were compared with chi-square tests or, when appropriate, Fisher's exact tests. The level of statistical significance was .05. Statistical analysis was performed with STATA 10 software (StataCorp., LP, College Station, TX, USA).

Results

Characteristics of cases and controls are shown in Table 1. They differed significantly for the distribution of geographic region: there were more women in the DOM among the cases than controls (12.8% compared with 4.1%). Women in Ile-de-France were also overrepresented among the women who died (29.9% compared with 21.3%, $p < 0.001$). Compared with controls, cases were significantly older and more often of foreign nationality. Among cases from continental France, clinical information obtained through the enquiry was available for 74.8% (N=214). Compared with controls, cases were more likely to be multiparous, to have been hospitalized during pregnancy and to have had a hypertensive disorder during pregnancy. The proportions of induced labor, emergency cesarean deliveries, and preterm deliveries were all significantly higher among cases than controls (Table 1).

The risk of postpartum maternal death was 4 times higher for women from the DOM and 1.8 times higher for those from Ile-de-France, compared with the rest of continental France. After

taking age and nationality into account, the adjusted odds ratio (aOR) was 3.5 (95% CI: 2.4, 5.0) for the DOM and 1.6 (95% CI: 1.2, 2.0) for Ile-de-France (Table 2).

Figure 3 shows the distribution of causes of death among the cases, according to region. Haemorrhage was the most important cause of MM in both the DOM (40.5%) and Ile-de-France (34.7%), whereas indirect causes were the leading cause in rest of continental France (34.0%). Further analysis of the risk for cause-specific MM associated with region showed, after adjustment for age and nationality, that the risk of mortality from all main causes of direct maternal death was significantly higher in Ile-de-France and the DOM (Table 2). The risk of death from hypertensive disorders and haemorrhage was 5.6 and 6.5 times higher, respectively, in the DOM and 2.7 and 2.3 times higher in Ile-de-France, compared with women in the rest of continental France (Table 2). The risk of maternal death from indirect obstetric causes did not differ significantly by regions.

After adjustment for socio-demographic and obstetric factors (parity, hospitalization during pregnancy and emergency cesarean), women in Ile-de-France had a higher risk of postpartum maternal death (aOR 1.8; 95% CI: 1.3, 2.6) than women in other continental regions (Table 3). The analysis by specific cause of death showed that the risk of postpartum death from haemorrhage was higher in Ile-de-France than in the rest of continental France (aOR 2.2, 95% CI: 1.2, 4.0). After excluding multiple and preterm deliveries, we repeated this analysis and obtained similar results (Table 3).

The National Expert Committee concluded that among the women who died (all causes included) women in the Ile-de-France received non-optimal care (64.8%) more often than those from the rest of continental France (43.4%, p =.01). Similarly, maternal deaths were avoidable more often in Ile-de-France (45.1%) than elsewhere in continental France (35.0%), although this difference was not statistically significant (Table 4).

Moreover, among the avoidable deaths, the reasons differed between Ile-de-France and the rest of continental France. Avoidability was related to “delay in treatment’’ more often in Ile-de-France (37.5%) than in the other continental regions (26.5%). “Inadequate or insufficient treatment” was the least frequent reason for avoidable maternal deaths in Ile-de-France (6.3%) and the leading reason (28.6%) elsewhere (Table 4). However, these differences were not statistically significant.

Discussion

The risk of postpartum maternal death is clearly higher for women in Ile-de-France and in the DOM (French Guyana, Guadeloupe, Martinique and Ile de la Reunion) than in the other regions of continental France. The excess MM in these regions was especially high for direct obstetric causes, that is, haemorrhages, pregnancy-related hypertension and amniotic fluid embolisms, and, for the DOM, thromboembolisms as well. In addition, we observed differences in the quality of care for the women who died between Ile-de-France and the rest of continental France; unfortunately this analysis could not be performed in the DOM.

These results, suggesting mechanisms of MM that have not been explored until now, must nonetheless be considered cautiously in view of the study's limitations.

The number of maternal deaths is small and generally limits our statistical power. This is one of the reasons that we chose a geographic division into three broad areas. These areas are not homogeneous in terms of demographic, geographic and economic characteristics. Ile de France, the highly urbanized region around the capital, and the DOM located in tropical and subtropical areas, each have a specific profile. The other regions of continental France are diverse, to the point that combining them creates a sort of national average. Nonetheless, the legislation and regulations, especially related to health and health care, are common to the entire country. Clinical information could not be collected for 25% of the potentially

postpartum maternal deaths identified by the ENCMM, because the local clinicians did not participate. The only available data were thus those on the death certificate. These deaths therefore could not be included in the analyses involving either the women's obstetric characteristics or the quality of their care. Nonetheless, this would induce bias only if the deaths that could not be investigated differed in nature from the deaths for which information could be collected, or if they were distributed differently between Ile-de-France and the rest of continental France. The distribution by region of uninvestigated cases did not differ from that of the cases that were studied. Moreover, the women's age, and nationality did not differ between the 2 groups, nor did the distribution of the causes of death (results not shown). Accordingly, the cases studied provide an acceptable sample that accurately reflects all the maternal deaths.

The limited number of individual covariables, in particular socio-economic characteristics, included in the analysis is also a limitation. Nonetheless two important known risk factors — age, which is a primordial factor in terms of risk of death, and nationality — could be considered for all the women [8-10, 16].

The clinical characteristics (parity, hospitalization during pregnancy, and emergency cesarean) are not especially refined, but they can be considered as a proxy for the mother's health status, during pregnancy and, to some extent, at delivery. Residual confounding cannot be excluded, in particular educational level, income [17], obesity [18], or inadequacy of prenatal care [19]. The regional environment, in particular the socio-economic context, such as the *deprivation index* [20], working and commuting conditions, especially transportation to the different health-care facilities where women might be seen according to their health status, have not been studied because this type of information was not available. A different study protocol would be required to take them into account.

We will discuss Ile-de-France and the DOM separately.

The maternal age in Ile-de-France, higher on average than in the rest of France did not explain the excess MM - older women being at higher risk of dying [10, 16, 21]- nor did the higher proportion of women from foreign countries, principally sub-Saharan Africa [8, 22], in this region. The persistence of excess postpartum mortality, after adjustment for relevant clinical characteristics, suggests that this is not explained by the prevalence of obstetrical complications; in addition, though the attractive effect of Ile-de-France medicalization does exist, our study population included only women who gave birth in their region of residence to exclude *referral bias*.

The heterogeneity between regions in the quality of care provided by the healthcare system is another explanation of the regional variations in MM. This hypothesis is especially interesting in that the causes of death for which there is a significant excess risk in Ile de France are direct obstetric causes, in particular postpartum haemorrhages and complications of pregnancy-related hypertension.

The experts' judgment about the quality of care, based on a meticulous reconstruction of each maternal death, shows that suboptimal care was more frequent in Ile-de-France than in the other regions of continental France. This result might seem paradoxical, given the high density in this region of specialized centers offering a very high level of care and especially the significantly higher proportion of level 3 maternity units [14]. It appears to contradict the results of a US study that showed that the density of such specialized centers was significantly and inversely associated with the MM rate [12]. This result must not be immediately interpreted as a demonstration of poor performance by the obstetric care system, it must be considered only as a warning signal of possibly inadequate care.

For a more complete judgment, we would need to know how all severe complications were handled by the system. Only a prospective population-based study of severe maternal morbidity can provide such a judgment. The data from our study about the reasons for

suboptimal care provide markers extremely useful in designing such a study. The fact that "delay in intervention" and "missed diagnosis" were more frequent among the maternal deaths considered avoidable in Ile-de-France, where the highest excess risk is for death from complications of hypertension and then from postpartum haemorrhages suggests that a detailed study of the following factors would be useful: the role of interhospital transfers, flaws in the continuity of care, potential work overloads or inadequate staffing, or both, as well as the possibility that patients may be negligent in seeking care or complying with prescriptions or other doctors' orders. Delays in care may be especially important for these causes, for which serious complications could be either prevented or treated more rapidly [23].

Insufficient data from the DOM prevented us from advancing far in the analysis of excess maternal deaths, whether related to the women's clinical characteristics or the quality of care. It is still more regrettable that we were unable to study these aspects for the DOM, for the women in these districts are more often multiparous, have fewer prenatal visits and are hospitalized more often during pregnancy [14]. Nonetheless, this first result that maternal mortality excess in the DOM is not explained by maternal age or nationality attracts attention to this population and will help to develop studies focused more directly on the local determinants. Such studies are all the more necessary in that our results are consistent with the results of other studies of reproductive health, which show a poorer health status globally throughout the DOM [24].

Conclusion

Regional differences in maternal mortality in France are not explained by individual characteristics in this study. Although we cannot exclude the implication of socio-economic factors that were incompletely characterized, this analysis suggests that disparities exist in the

provision of care and flaws in the organization of the healthcare system. The hypotheses that the application of national clinical guidelines may differ from region to region or that the resources are used or mobilized differently should be explored.

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5.-Disclosure of Interests

The authors have no potential conflicts of interest to disclose.

6.-Contribution to Authorship

M.S. conducted the analysis, drafted and revised the article. C.D-T had the original idea for this study. M-H.B-C. has coordinated the confidential national survey on maternal deaths in France since 1996. C.D-T. and M-H.B-C., both collaborated in the drafting and revision of the paper.

7.-Details of ethics approval

The Confidential Enquiry into Maternal Deaths (ENCMM) and the National Perinatal Survey (NPS) were approved by The Commission nationale de l'informatique et des libertés (National Data Protection Authority).

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9.-References

1. Atrash HK, Alexander S, Berg CJ. Maternal mortality in developed countries: not just a concern of the past. Obstet Gynecol. 1995 Oct;86(4 Pt 2):700-5.
2. Berg CJ, Harper MA, Atkinson SM, Bell EA, Brown HL, Hage ML, et al. Preventability of pregnancy-related deaths: results of a state-wide review. Obstet Gynecol. 2005 Dec;106(6):1228-34.
3. Graham WJ. Now or never: the case for measuring maternal mortality. Lancet. 2002 Feb 23;359(9307):701-4.
4. Bouvier-Colle MH. [Confidential enquiries and medical expert committees: a method for evaluating healthcare. The case of Obstetrics]. Rev Epidemiol Sante Publique. 2002 Apr;50(2):203-17.
5. Report of the National Expert Committee on Maternal Mortality (CNEMM), France 2001-2006. Institut de veille sanitaire; 2010. Available from: http://www.invs.sante.fr/publications/2010/mortalite_maternelle/rapport_mortalite_maternelle_anglais.pdf
6. Cantwell R, Clutton-Brock T, Cooper G, Dawson A, Drife J, Garrod D, et al. Saving Mothers' Lives: Reviewing maternal deaths to make motherhood safer: 2006-2008. The Eighth Report of the Confidential Enquiries into Maternal Deaths in the United Kingdom. BJOG. 2011 Mar;118 Suppl 1:1-203.
7. Schutte JM, Steegers EA, Schuitemaker NW, Santema JG, de Boer K, Pel M, et al. Rise in maternal mortality in the Netherlands. BJOG. 2010 Mar;117(4):399-406.
8. Philibert M, Deneux-Tharaux C, Bouvier-Colle MH. Can excess maternal mortality among women of foreign nationality be explained by suboptimal obstetric care? BJOG. 2008 Oct;115(11):1411-8.

9. Stirbu I, Kunst AE, Bos V, Mackenbach JP. Differences in avoidable mortality between migrants and the native Dutch in The Netherlands. BMC Public Health. 2006;6:78.
10. Temmerman M, Verstraelen H, Martens G, Bekaert A. Delayed childbearing and maternal mortality. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2004;114(1):19-22.
11. Saucedo M, Deneux-Tharaux C, Bouvier-Colle MH. Regional disparities in maternal mortality in France: specificities of Ile-de-France region and French overseas departments, 2001-2006. Bulletin épidémiologique hebdomadaire (France). 2010 Jan(2-3):15-8.
12. Sullivan SA, Hill EG, Newman RB, Menard MK. Maternal-fetal medicine specialist density is inversely associated with maternal mortality ratios. American Journal of Obstetrics and Gynecology. 2005;193(3, Supplement 1):1083-8.
13. World Health Organisation. ICD 10: international statistical classification of diseases and related health problems. 10th revision. Geneva (Switzerland): World Health Organization; 1992.
14. B. Blondel, K. Supernant, C. du Mazaubrun and G. Bréart, Enquête nationale périnatale 2003. Situation en 2003 et évolution depuis 1998, Inserm Unité 149, Paris (2005) p. 51. Available from: http://www.sante.gouv.fr/IMG/pdf/ENP_2003_rapport_INSERM.pdf.
15. Blondel B, Supernant K, Du Mazaubrun C, Breart G. [Trends in perinatal health in metropolitan France between 1995 and 2003: results from the National Perinatal Surveys]. J Gynecol Obstet Biol Reprod (Paris). 2006 Jun;35(4):373-87.
16. Callaghan WM, Berg CJ. Pregnancy-related mortality among women aged 35 years and older, United States, 1991-1997. Obstet Gynecol. 2003 Nov;102(5 Pt 1):1015-21.

17. Maine D. How do socioeconomic factors affect disparities in maternal mortality? J Am Med Womens Assoc. 2001 Fall;56(4):189-90, 92.
18. Cevik B, Ilham C, Orskiran A, Colakoglu S. Morbid obesity: a risk factor for maternal mortality. Int J Obstet Anesth. 2006 Jul;15(3):263-4.
19. Harper MA, Byington RP, Espeland MA, Naughton M, Meyer R, Lane K. Pregnancy-related death and health care services. Obstet Gynecol. 2003 Aug;102(2):273-8.
20. Rey G, Jougla E, Fouillet A, Hemon D. Ecological association between a deprivation index and mortality in France over the period 1997 - 2001: variations with spatial scale, degree of urbanicity, age, gender and cause of death. BMC Public Health. 2009;9:33.
21. Breart G. Delayed childbearing. European Journal of Obstetrics & Gynecology and Reproductive Biology. 1997;75(1):71-3.
22. Ibison JM, Swerdlow AJ, Head JA, Marmot M. Maternal mortality in England and Wales 1970-1985: an analysis by country of birth. Br J Obstet Gynaecol. 1996 Oct;103(10):973-80.
23. Driessen M, Bouvier-Colle MH, Dupont C, Khoshnood B, Rudigoz RC, Deneux-Tharaux C. Postpartum haemorrhage resulting from uterine atony after vaginal delivery: factors associated with severity. Obstet Gynecol. 2011 Jan;117(1):21-31.
24. Bazely P., Catteau C. État de santé, offre de soins dans les départements d'Outre-Mer (Guadeloupe, Guyane, Mar tinique, Réunion). Paris : Drees, coll. Série études, n°14, juin 2001. Available from: http://www.sante.gouv.fr/IMG/pdf/serieetud14.pdf

10.- List of tables

Table 1. Distribution of characteristics of women and deliveries among cases and controls.

	Cases (n=328)	Controls (n=14878)	*p* value [a]
Region	**328**	**14878**	**<0.001**
Ile-de-France	29.9	21.3	
Overseas districts (DOM)	12.8	4.1	
Rest of continental France	57.3	74.6	
Age	**328**	**14687**	**<0.001**
<25	11.6	19.2	
25-34	47.3	64.7	
35+	41.2	16.1	
Nationality	**328**	**14469**	**<0.001**
French	80.8	88.0	
Foreign	19.2	12.0	
Marital status	**328**	**14423**	0.4
Married	50.0	52.4	
Not married	50.0	47.6	
Work status	**286**	**14212**	0.8
Yes	60.8	60.1	
No	39.2	39.9	
Only continental France [b]	(n=214)[c]	(n=14269)	
Parity	**182**	**14050**	<0. 001
0	21.9	43.3	
1-3	63.2	53.8	
More than 3	14.8	2.9	
Hospitalization during pregnancy	**188**	**13825**	<0.001
No	68.6	81.4	
Yes	31.4	18.6	
Hypertensive disorder during pregnancy	**187**	**14112**	0.001
No	90.4	95.4	
Yes	9.6	4.6	
Induced labor	**195**	**14234**	<0.001
No	38.5	67.8	
Yes	61.5	32.1	
Mode of delivery	**209**	**14230**	<0.001
Vaginal	38.2	80.4	
Caesarean	60.8	19.6	
Emergency caesarean	**208**	**14010**	<0.001
No	47.1	90.2	
Yes	52.9	9.8	
Preterm delivery	**198**	**14204**	<0.001
No	67.2	93.6	
Yes (less than 37 wk)	32.8	6.4	
Multiple birth	**211**	**14269**	0.03
No	96.2	98.2	
Yes	3.8	1.8	

[a] For chi2 test.
[b] Ile-de-France and the rest of continental regions,
[c] Only postpartum maternal deaths reviewed by the National Committee of Experts

401 Table 2. Overall and cause-specific postpartum maternal mortality associated with region, crude and adjusted odds ratios (controlling for socio-
402 demographic factors).

Causes of death	Region	Cases	Controls	Crude OR	95% CI	adjusted OR[a]	95% CI
All causes	DOM	42	**609**	**4.1**	2.9 - 5.7	**3.5**	2.4 – 5.0
	Ile-de-France	98	**3166**	**1.8**	1.4 - 2.3	**1.6**	1.2 – 2.0
	Rest of continental France	188	**11103**	**1**		**1**	
Haemorrhage	DOM	17		7.6	4.2 – 13.4	**6.5**	3.6 – 11.6
	Ile-de-France	34		2.9	1.8- 4.6	**2.3**	1.4 – 3.7
	Rest of continental France	41		**1**		**1**	
Amniotic fluid embolism	DOM	5		3.1	1.2 – 8.1	**2.8**	1.1 – 7.3
	Ile-de-France	21		2.5	1.4 – 4.6	**2.1**	1.2 – 3.8
	Rest of continental France	28		**1**		**1**	
Thromboembolism	DOM	4		3.8	1.3 – 11.3	**3.3**	1.1-9.8
	Ile-de-France	4		0.7	0.3 – 2.2	0.6	0.2 – 1.9
	Rest of continental France	20		**1**		**1**	
Hypertensive disorders	DOM	4		6.6	2.1 – 20.9	**5.6**	1.7 – 17.7
	Ile-de-France	9		2.9	1.2 – 6.9	**2.7**	1.1 – 6.8
	Rest of continental France	11		**1**		**1**	
Other direct causes[b]	DOM	8		6.1	2.7 – 13.6	**5.2**	2.3-11.8
	Ile-de-France	16		2.3	1.2 – 4.4	**1.9**	1.0 – 3.7
	Rest of continental France	24		**1**		1	
Indirect causes	DOM	4		1.1	0.4 – 3.1	1.0	0.4 – 2.8
	Ile-de-France	14		0.8	0.4 – 1.4	0.8	0.4 – 1.3
	Rest of continental France	64		**1**		**1**	

403 Data for the columns for cases and controls are numbers.
404 DOM, overseas districts; OR, odds ratio; CI, confidence interval.
405 [a] Logistic model including maternal age and nationality
406 [b] Complications of anaesthesia, infections and other complications directly related to pregnancy

Table 3. Overall and cause-specific postpartum maternal mortality associated with region in continental France, crude and adjusted odds ratios (controlling for socio-demographic and obstetric factors).

	Cases		Controls		Crude OR	95% CI	Adjusted OR[a]	95% CI
Causes of death	Rest of continental France	Ile-de-France	Rest of continental France	Ile de France				
All causes	**143 (100)**	**71 (100)**	**11103**	**3166**	1.7	1.3 – 2.3	**1.8**	1.3 – 2.6
Haemorrhage	29 (20.3)	22 (31.0)			2.7	1.5 – 4.6	**2.2**	1.2 – 4.0
Amniotic fluid embolism	23 (16.1)	13 (18.3)			1.9	1.0 – 3.7	1.8	0.8 – 3.8
Indirect causes	56 (39.2)	14 (19.7)			0.9	0.5 – 1.6	0.7	0.3 – 1.6
Singleton term deliveries only								
All causes	**78 (100)**	**49 (100)**	**10252**	**2909**	2.2	1.5 – 3.2	**2.3**	1.5 – 3.5
Haemorrhage	19 (24.4)	18 (36.7)			3.3	1.8 – 6.4	**2.8**	1.3 – 5.9
Amniotic fluid embolism	21 (26.9)	12 (24.5)			2.0	1.0 – 4.1	**2.1**	1.0 – 4.7

Data for the case column are numbers (%).
OR, odds ratio; CI, confidence interval.
[a] Logistic model including maternal age, nationality, parity, hospitalization during pregnancy and emergency caesareans.

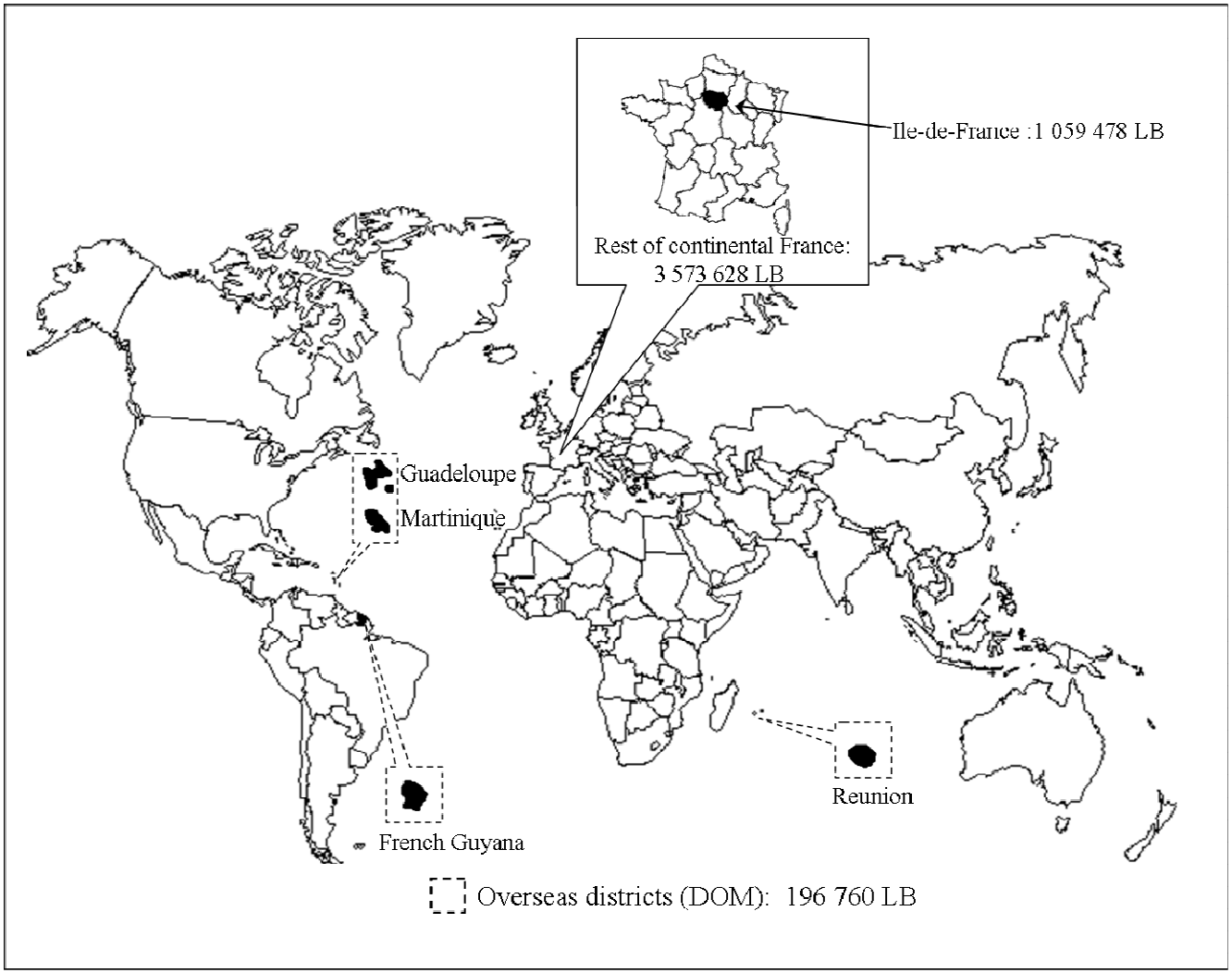
Table 4. Expert judgment about the quality of care and avoidability of postpartum maternal deaths according to region.

	Ile-de-France	Rest of continental France	*p* value
General quality of care	**(N=71)**	**(N=143)**	
Optimal	19.7	28.6	0.01
Not optimal	64.8	43.4	
Could not be determined	15.5	28.0	
Avoidability of death according to the experts	**(N=71)**	**(N=143)**	
Not avoidable	33.8	49.0	0.1
Avoidable[a]	45.1	35.0	
Could not be determined	21.1	16.0	
Reasons (if death was avoidable)	**(N=32)**	**(N=50)**	
Delay in treatment (therapeutic or intervention)	37.5	26.5	0.07[b]
Inadequate or insufficient treatment	6.3	28.6	
Medical error	25.0	26.5	
Missed diagnosis	21.8	16.4	
Negligence of the patient	9.4	2.0	

[a] Certainly avoidable or perhaps
[b] Fisher's exact test
Data are %, unless otherwise specified.

418 Figure 1.

419 Map of study sites and corresponding numbers of live births (LB), France 2001-2006.



420

Figure 2

Selection of cases and controls.

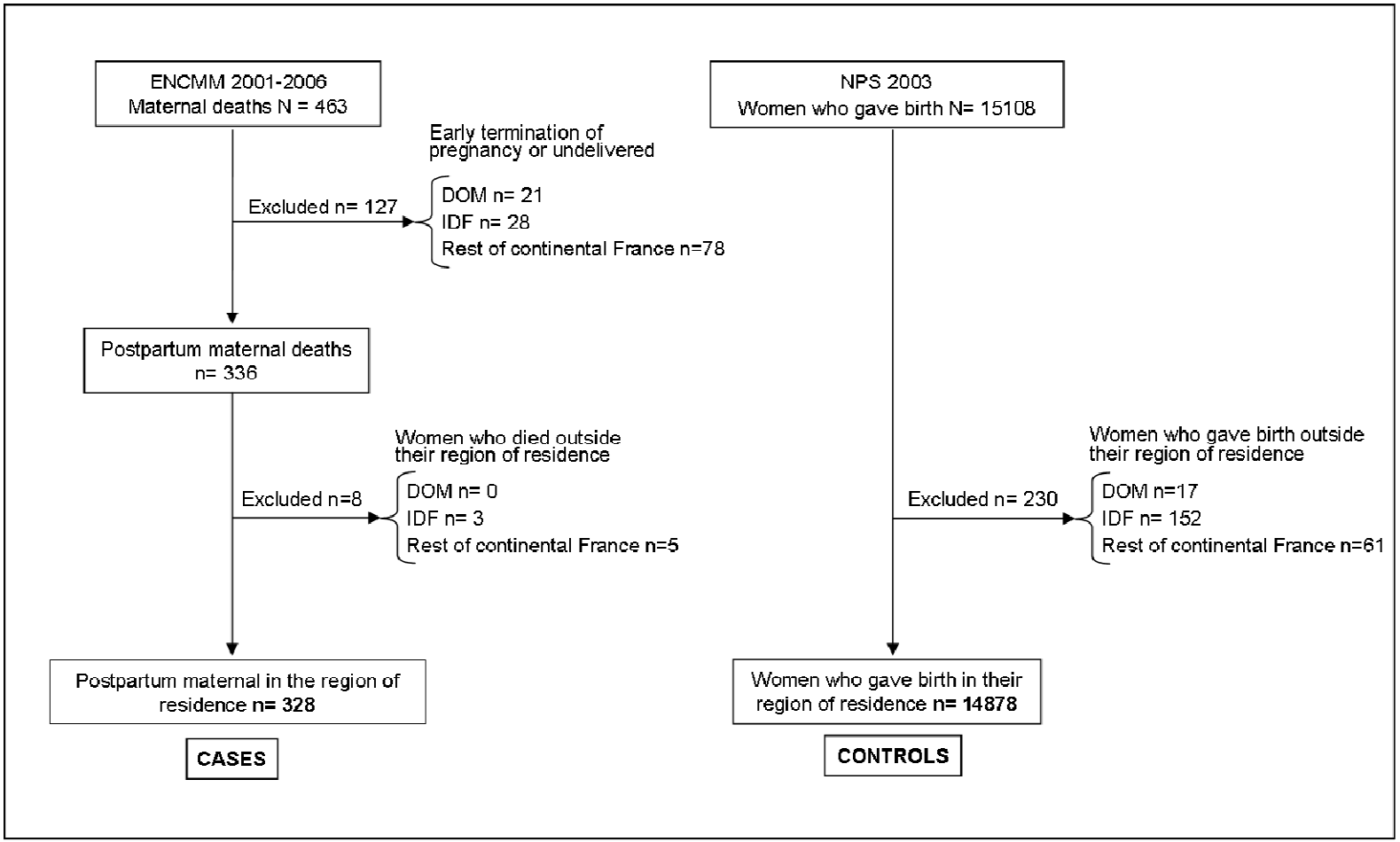


Figure 3.

Distribution of causes of postpartum maternal deaths, percentage by region.